IN THE CLAIMS

1. (Currently Amended) A method ~~fox~~ for controlling the attitude of a satellite equipped with an attitude control system in a reference coordinate system (X, Y, Z) for positioning the satellite, ~~and comprising at least three actuators called main actuators~~

the method comprising:

providing the attitude control system that comprises

no more than three primary actuators including two control moment gyros and one Z-axis actuator, the two ~~of which are~~ control moment gyros each ~~having~~ comprising

a rotor connected to a steerable gimbal, each rotor having a fixed axis with respect to the steerable gimbal, each gimbal having a fixed axis with respect to the satellite, the fixed axis of each rotor being perpendicular with respect to the fixed axis of its connected gimbal, the gimbal axes being parallel to each other and the Z-axis,

[[a]] each rotor driven ~~so as~~ to rotate about [[a]] its fixed ~~rotation~~ axis ~~with respect to a~~ to orient its connected steerable gimbal ~~that can be oriented~~ about the fixed axis of said gimbal, ~~a gimbal axis perpendicular to the rotation axis of the corresponding rotor, and stationary with respect to the satellite, characterized in that:~~

~~the gimbal axes of the two control moment gyros are fixed so that these gimbal axes are parallel to each other and to the Z axis,~~

a third Z-axis actuator delivering torque in at least one direction not lying in a (X, Y) plane,

wherein ~~the~~ angular momentum vectors (H_1, H_2) of the control moment gyros ~~therefore moving~~ move in the (X, Y) plane and ~~making~~ define between them an angle (α) which~~, by definition, corresponds~~ is related to a

skew angle (ε), wherein ε = 180 - α between the angular momentum vectors (H_1, H_2) when α is ~~different from~~ greater than 0° and less than 180°;

~~in addition to the two control moment gyros, at least a third~~ using the ~~main~~ Z-axis actuator ~~is used as a complement,~~ for delivering torques ~~in both senses~~ in at least one direction not lying in the (X, Y) plane~~, so that this third main actuator is called the Z-axis main actuator~~;

imparting a sufficiently small nonzero skew angle (ε) between the angular momentum vectors (H_1, H_2) of the control moment gyros ~~is imparted, said skew angle (ε) preferably being chosen to be small enough~~ to avoid ~~not to create~~ an excessively large internal angular momentum on board the satellite, the nonzero skew angle (ε) being ~~but~~ large enough to ensure controllability of the attitude control system along the three axes (X, Y, Z) without ~~necessarily~~ having to modify the rotation speed of the rotor of at least one of the control moment gyros;

estimating ~~the~~ kinematic and dynamic variables~~, which are necessary for controlling the attitude of the satellite, such as for example the~~ including attitude angles and angular velocities of the satellite along the ~~three~~ X, Y and Z axes~~, are estimated~~ from measurements provided by sensors ~~used~~ disposed on board the satellite;

calculating setpoint variables~~, intended to allow objectives assigned to the satellite attitude control system to be achieved, such as for example the~~ for controlling a desired attitude of the satellite with respect to ~~tilting and pointing along at least one of~~ the three axes of the (X, Y, Z) coordinate system~~, are calculated~~; and

calculating control commands ~~are calculated,~~ from differences between said estimated kinematic and dynamic variables and said setpoint variables, ~~and then sent to the main actuators, these control commands being intended to control the change in said differences over time, said control commands transmitted to the control moment gyros comprising at least commands intended~~ the control commands comprising commands to vary the orientation of ~~their~~ the gimbal axes of the control moment gyros, ~~such as for example~~ to provide gimbal angular position setpoints ~~that have to be generated by a~~ for local position feedback control, ~~or~~ and to provide electric current setpoints~~, for currents that have to be~~

~~injected into motors~~ for current delivered to rotors used for orienting the gimbal axes of the control moment gyros,

wherein the control commands that are intended to vary the orientation of the gimbal axes of the control moment gyros and limit a range of variations of the angle (α) within a specified angular range greater than 0° and less than180°;

sending the calculated control commands to the three primary actuators.

2. (Currently Amended) The control method as claimed in claim 1, characterized in that, during an initialization phase of the attitude control system,

modifying the angle (α) ~~between the angular momentum vectors (H1, H2) of the two control moment gyros is brought~~ to a value ~~substantially different from~~ less than 180°, using at least one secondary actuator ~~on board the satellite, for the purpose of substantially and cumulatively modifying the angular momentum of said satellite in at least one direction in the (X,Y) plane and/or optionally the Z-axis main actuator in the case in which the latter is used to generate~~ by generating an angular momentum component in the (X,Y) plane.

3. (Currently Amended) The control method as claimed in claim [[2]] 9, further comprising:

providing the at least one secondary actuator, wherein the secondary actuator is selected from the group consisting of ~~characterized in that at least one of the following members is used as secondary actuator:~~ magnetic-torquers, jet actuators, torque actuators ~~of any other type~~, ~~these preferably being selected from those of said aforementioned members necessarily used on board the satellite~~ for carrying out operations other than ~~the~~ normal modes of operation of the satellite.

4. (Currently amended) The attitude control method as claimed in ~~either of~~ claim [[s]] 2 ~~and 3~~, ~~characterized in that~~ further comprising:

~~at least one actuator to generate torques along one two or three axes of the reference coordinate system, the effect of which together with the satellite attitude control system is, simultaneously or sequentially, to modify~~

modifying the angle (α) between the angular momentum vectors (H_1 and H_2) of the control moment gyros so that said angle (α) remains within a specified range and,

~~and/or in that, simultaneously, or sequentially, said Z-axis main actuator can also be desaturated, especially when said~~ desaturating the Z-axis ~~main~~ actuator, and

wherein the Z-axis actuator comprises ~~at least~~ one reaction wheel ~~whose angular momentum must remain, in terms of modulus, below a given limit~~.

5. (Currently Amended) The control method as claimed in ~~any one of~~ claim [[s]] 1 ~~to 4~~, characterized in that ~~the~~ a total angular momentum of the two control moment gyros, resulting from the skew (ε) angle between the angular momentum vectors (H_1, H_2) of said control moment gyros, is oriented in a direction normal to the orbital plane of the satellite.

6. (Currently Amended) The control method as claimed in ~~any one of~~ claim [[s]] 1 ~~to 5~~, characterized in that ~~the~~ a total angular momentum of the ~~pair of~~ two control moment gyros, resulting from the skew (ε) angle between the angular momentum vectors (H_1, H_2) of the two control moment gyros, is compensated for by the projection in the (X,Y) plane of the cumulative specific moment ~~to this effect~~ by ~~said third,~~ the Z-axis ~~main~~ actuator.

7. (Currently amended) The control method as claimed in ~~any one of~~ claim[[s]] 1 ~~to 6~~, ~~characterized in that~~ further comprising:

establishing a setpoint configuration for the ~~pair of~~ two control moment gyros[[,]] ~~away from the singular configurations for which the angle (α) is zero or equal to 180°, and possibly a temporal Z-axis angular momentum profile that has to be performed by the third, Z-axis main actuator are determined~~ from ~~the~~ initial and final conditions of the satellite ~~in terms of attitude angles, angular velocity and time, in such a way~~ so that ~~the~~ an angular momentum exchange~~, over an imposed time,~~ between the satellite[[,]] and the two control moment gyros is brought into said setpoint configuration and

generating a desired attitude maneuver with the Z-axis ~~third~~ actuator, ~~brings about the desired attitude maneuver,~~ the Z-axis actuator comprising a reaction wheel; and

rotating the rotors using an open-loop servocontrol to orient ~~the orientation of the~~ each gimbal ~~of each of the control moment gyros is brought, simultaneously and possibly independently, into its~~ within the setpoint configuration ~~orientation thanks to an angular position setpoint sent, in open loop, into a local servocontrol for controlling the angular position of the gimbals~~; and

generating a ~~the~~ Z-axis angular momentum profile ~~is generated~~ by varying a speed of the reaction wheel~~, simultaneously and possibly independently, using the third, Z-axis main actuator, advantageously at least one reaction wheel, the rotation speed of which will consequently be varied~~.

8. (Currently Amended) The control method as claimed in claim 7,

further comprising:

~~characterized in that, on the basis of differences observed in the generation of a maneuver profile with respect to a predefined setpoint profile,~~ adding closed-loop commands ~~are added~~ to the open-loop servocontrol ~~setpoints sent to the main actuators so as to reduce said differences~~.

9. (New) The control method as claimed in claim 1, characterized in that, during an initialization phase of the attitude control system, the method further comprises:

modifying the angle (α) to a value ~~substantially different from~~ less than 180°, using at least one secondary actuator for modifying the angular momentum of said satellite in at least one direction in the (X,Y) plane.

10. (New) The attitude control method as claimed in claim 3, further comprising:

using the at least one secondary actuator to generate torques along one or more of the X, Y or Z, axes of the reference coordinate system, and

desaturating the Z-axis actuator.